In relation to D1 we submit that the flexible hose must be elastic for two reasons.

1. Each end of the flexible hose is fixed at both ends with no ability of those ends to move towards or away from each other. Hence, if the flexible hose was inelastic the length of the tube would need to decrease in longitudinal length as the flexible hose moves from an expanded to contracted condition. As movement between the ends of the flexible hose is not permitted in D1 the only way the hose can move between conditions is if it had a degree of elasticity.

2. The flexible hose is located on the inside of tubular housing 2, with each end of the flexible hose extending beyond the end of the housing before being turned back to overlap the end of the housing. We submit that in order to secure the flexible hose in this manner the flexible hose would require to be elastic.

In relation to D2 your report suggests that as evidence of the shape of the diaphragm 20 in the figures, the diaphragm must be inelastic. Again it would appear that the diaphragm in D2 is fixed at both ends and hence in order to be inelastic and be able to move between expanded and contracted positions the diaphragm cannot be taut when the diaphragm is in the contracted condition. We submit that as the diaphragm is fixed at both ends either the diaphragm is elastic in order to accommodate expanded and contracted conditions, or the diaphragm is in elastic but not maintained in a taut condition when the diaphragm is in the contracted condition.

We respectfully submit that in light of the inclusion of the features of claim 4 in claim 1 and the above argument, the present invention is novel and inventive over D1 and D2.

In relation to citation JP 11117872 (D3) we submit that the pumping system does not expel an uninterrupted supply of fluid. Looking at figure 7 of D3 it is apparent that there is no overlap between the discharge of one pump and the discharge of the other. As piston head 46a and piston head 46b are connected to the same rod, the discharge of one pump can only commence once the discharge of the other has been completed. As such the flow provided through outlet 43 will be a pulsating flow. This is further accentuated by the lack of precharge in each chamber 41a, 41b to assist in increasing the pressure in the chamber before the discharge from that chamber commences. As such, the piston head must first move an initial amount to create the necessary pressure within the chamber to overcome valve 44, and the pressure in the pipe between valve 44 and the outlet 43.

In light of our above comments, and the deletion of claim 46 we submit that the current invention is novel and inventive over D3.

In relation to US 4543044 (D4) and US 5114319 (D5) we submit that the current application is now both novel and inventive in light of the deletion of claims 46 and 47.

In light of the above amendments and arguments we submit that the combination of any of the remaining documents with D1 to D5, does not render the invention of the above application lacking an inventive step.

We respectfully request your favourable reconsideration.

Yours faithfully
WRAY & ASSOCIATES

Scott Vilé

Enc: Statement of Proposed Amendments
Marked up specification
Amended specification
Drawing page 15/15

COMMONWEALTH OF AUSTRALIA

The Patents Act 1990

IN THE MATTER of International Patent Application PCT/AU03/00953.

Amendments Under Article 34

In The Claims

i) Claim 1 amended to include features of claim 4

ii) Claims 3, 4, 46 and 47 deleted

iii) Claim 38 amended to attend to antecedent issue

iv) Claim 14 amended to attend to antecedent issue

v) Remaining claims renumbered

In The Description

vi) Page 2 and 3 currently on file, amended to reflect changes to claim 1 and deletion of claim 4.

vii) Page 7 currently on file, amended to reflect changes to claim 38.

Drawings

viii) Figure 18 amended to correct error in numbering valves with respect to chamber 22.

Abstract

ix) Abstract has been renumbered.

end, with a pumping chamber defined within the tube between the supply and discharge ends. Fluid pressure is employed to compress the tube, thereby urging a charge of the fluid within the pumping chamber towards the discharge end. Various proposals for such pumps are disclosed in US 3,406,633 (Schomburg), US 4,515,536 (van Os), US 6,345,962 (Sutter), GB 2195149 (SB Services (Pneumatics) Ltd), WO 82/01738 (RIHA), US 4,257,751 (Kofahl) and US 4,886,432 (Kimberlin).

Each of these proposals utilise a flexible tube which is elastic so that it is compressible to expel the charge of fluid therein and expandable to receive a further charge of pumped fluid into theflexible tube. Each of these proposals has limitations on the maximum pressure to which the device can operate. The limitation is a result of the maximum pressure differential the flexible tube can withstand if the tube is over-compressed by the pumping fluid. If over-compressed the tube will fail by rupturing at the outlet port.

It is against this background, and the deficiencies and problems associated therewith that the present invention has developed.

The reference to the abovementioned prior art is for the purposes of background only and is not, and should not be taken as, an acknowledgement or any form of suggestion that the prior art forms part of the general knowledge in Australia.

Disclosure of the Invention

According to a first aspect of the invention there is provided a pump for conveying a pumped fluid using a actuating fluid, the pump comprising a rigid outer casing defining an interior space, a tube structure accommodated in the interior space, the tube structure being flexible and substantially inelastic, the interior of the tube structure defining a pumping chamber for receiving pumped fluid, the tube structure being movable between laterally expanded and collapsed conditions for varying the volume of the pumping chamber thereby to provide discharge and intake strokes the tube structure being maintained in a taut condition between the ends thereof, the region of the interior space surrounding the tube structure

defining an actuating region for receiving and accommodating actuating fluid, the pumping chamber being adapted to receive pumped fluid to cause the tube structure to move towards the expanded condition and the pumping chamber thereby undergoing an intake stroke, the pumping chamber undergoing a discharge stroke upon collapsing of the tube structure in response to the action of actuating fluid in the actuating region.

Preferably, one end of the tube structure is closed and the other end is connected to a port through which pumped fluid can enter into and discharge from the pumping chamber as the pumping chamber performs intake and discharge strokes.

~~Preferably, the tube structure is maintained in a taut condition between the ends thereof.~~

Preferably, the tube structure is supported at the closed end thereof.

Preferably, the closed end of the tube structure is movably supported to accommodate longitudinal extension and contraction of the tube structure. The closed end of the tube structure may be movably supported in any appropriate fashion such as by way of a spring mechanism.

Preferably the actuating region comprises an actuating annulus substantially surrounding the tube structure and an actuating chamber located at the closed end of the pump. Preferably the actuating annulus is in fluid communication with the actuating chamber.

Preferably the pump comprises means to bled fluid, such as air, therefrom.

Preferably the pump comprises separate means to bled air from the pumping chamber and from the actuating region, wherein the air is bled from the pumping chamber during the intake stroke and air is bled from the actuating region during the discharge stroke.

According to a fourth aspect of the invention there is provided a pumping system comprising

at least two pumps each having a pumping chamber accommodated in an actuating region,

a delivery means for delivering pumped fluid to each pumping chamber in timed sequence, causing each pumping chamber to undergo an intake stroke, and

means for supplying actuating fluid to each actuating region in timed sequence to cause ~~the~~ a respective tube structure of the pumping chamber to laterally collapse whereby the pumping chamber undergoes a discharge stroke,

whereby the sequential operation of the at least two pumps expels a generally uninterrupted supply of pump fluid from the pumping system.

Preferably each pumping chamber comprises a flexible and substantially inelastic tube structure.

Preferably the pumping chamber has one end closed and the other end connected to a port through which pumped fluid can enter into and discharge from the pumping chamber as the pumping chamber performs intake and discharge strokes. Preferably the closed end of the pumping chamber is elevated in relation to the other end thereof.

According to a fifth aspect of the invention there is provided a method of operating a pumping system in accordance with the fourth aspect of the invention wherein the duration of the discharge stroke of one pump is longer than the duration of the intake stroke of the other pump, and vice versa, whereby, when operated sequentially, the pumping system delivers a generally uninterrupted supply of fluid.

The Claims Defining the Invention are as Follows

1. A pump for conveying a pumped fluid using a actuating fluid, the pump comprising a rigid outer casing defining an interior space, a tube structure accommodated in the interior space, the tube structure being flexible and substantially inelastic, the interior of the tube structure defining a pumping chamber for receiving pumped fluid, the tube structure being movable between laterally expanded and collapsed conditions for varying the volume of the pumping chamber thereby to provide discharge and intake strokes, tube structure being maintained in a taut condition between the ends thereof, the region of the interior space surrounding the tube structure defining an actuating region for receiving and accommodating actuating fluid, the pumping chamber being adapted to receive pumped fluid to cause the tube structure to move towards the expanded condition and the pumping chamber thereby undergoing an intake stroke, the pumping chamber undergoing a discharge stroke upon collapsing of the tube structure in response to the action of actuating fluid in the actuating region.

2. A pump according to claim 1 wherein one end of the tube structure is closed and the other end is connected to a port through which pumped fluid can enter into and discharge from the pumping chamber as the pumping chamber performs intake and discharge strokes.

~~3.A pump according to claim 2 wherein the tube structure collapses progressively from the closed end to the other end.~~

~~4.A pump according to claims 1, 2 or 3 wherein the tube structure is maintained in a taut condition between the ends thereof.~~

~~5.~~3. A pump according to claims ~~2, 3 or 4~~1 or 2 wherein the tube structure is supported at the closed end thereof.

~~6.~~4. A pump according to any one of claims 2 to ~~5~~ 3 wherein the closed end of the tube structure is movably supported to accommodate longitudinal extension and contraction of the tube structure.

~~7.~~5. A pump according to any one of claims 2 to 6 wherein the closed end of the tube structure is movably supported in any appropriate fashion such as by way of a spring mechanism.

~~8.~~6. A pump according to any one of claims 2 to ~~7~~ 5 wherein the actuating region comprises a actuating annulus substantially surrounding the tube structure and a actuating chamber located at the closed end of the pump.

~~9.~~7. A pump according to claim ~~8~~ 6 wherein the actuating annulus is in fluid communication with the actuating chamber.

~~10.~~8. A pump according to any one of the preceding claims comprising means to bled fluid, such as air, from the pump.

~~11.~~9. A pump according to claim ~~10~~ 8 comprising separate means to bled air from the pumping chamber and actuating region~~.~~, wherein the air is bled from the pumping chamber during the intake stroke and air is bled from the actuating region during the discharge stroke.

~~12.~~10. A pump according to any one of the preceding claims comprising a monitoring means to monitor the pump during the intake and discharge stroke.

~~13.~~11. A pump according to claim ~~12~~ 10 wherein the monitoring means monitors the condition of the tube structure.

~~14.~~12. A pump according to claim ~~12 or 13~~ 10 or 11 wherein the ~~sensing~~ monitoring means monitors, directly or indirectly, the position of the closed end of the tube structure.

~~15.~~13. A pump according to claim ~~12~~ 10 wherein the monitoring means monitors the pressure differential between components of the pump.

~~16.~~14. A pump according to any one of claims ~~12 to 15~~10 to 13 wherein the monitoring means at least indicates when the discharge and intake strokes have been completed.

~~17.~~15. A pumping system comprising a pump in accordance with any one of claims 1 to ~~16~~14, a delivery means for delivering pumped fluid to the pumping chamber in timed sequence for causing the pumping chamber to undergo an intake stroke, and means for supplying actuating fluid to the actuating region in timed sequence to cause the tube structure to laterally collapse whereby the pumping chamber undergoes a discharge stroke.

~~18.~~16. A pumping system according to claim ~~17~~ 15 wherein the delivery means comprises a delivery pump.

~~19.~~17. A pumping system according to claim ~~17 or 18~~15 or 16 wherein the actuating fluid is of any appropriate form, such as hydraulic oil or water.

~~20.~~18. A pumping system according to claim ~~19~~ 17 wherein the actuating fluid is hydraulic oil.

~~21.~~19. A pumping system according to claim ~~20~~ 18 wherein the supply means includes a hydraulic circuit incorporating a reservoir for hydraulic oil and a hydraulic pump.

~~22.~~20. A pumping system according to claim ~~21~~ 19 wherein the hydraulic circuit also includes an intake and exit valve system for regulating the delivery of hydraulic oil into, and the discharge of hydraulic oil from, the actuating region in timed sequence.

~~23.~~21. A pumping system according to claim ~~19~~ 17 wherein the actuating fluid is water.

~~24.~~22. A pumping system according to claim ~~23~~ 21 wherein the supply means comprise a water reservoir at an elevated location in order to supply the water at the appropriate pressure head.

~~25.~~23. A pumping system according to any one of claims ~~17 to 24~~ 15 to 22 wherein the delivery of the actuating fluid to the actuating region is at an opposed end to the port through which pumped fluid enters into and discharges from the pumping chamber.

~~26.~~24. A pumping system according to any one of claims ~~17 to 25~~15 to 23 wherein the outlet of the actuating fluid from the actuating region is also at an opposed end to the port through which pumped fluid enters into and discharges from the pumping chamber.

~~27.~~25. A pumping system according to any one of claims ~~17 to 26~~15 to 24 comprising two pumps in accordance with claims 1 to ~~16~~ 14 operating sequentially such that the pumping chamber of one pump performs an intake stroke while the pumping chamber of the other pump performs a discharge stroke, and vice versa.

~~28.~~26. A pumping system according to claim ~~27~~ 25 wherein the sequential operation of the two pumps is such that a generally uninterrupted supply of pumped fluid is expelled from the pumping system.

~~29.~~27. A pumping system according to claim ~~27 or 28~~25 or 26 wherein the duration of the discharge stroke is longer than the duration of the intake stroke.

~~30.~~28. A pumping system according to claims ~~27, 28 or 29~~25, 26 or 27 wherein one pump completes its intake stroke and commences its discharge stroke while the other pump is completing its discharge stroke.

~~31.~~29. A pumping system according to any one of claims ~~27 to 30~~25 to 28 wherein the discharge stroke of one pump is completed by the time the

discharge from the other pump is equal in flow to the desired flow of pump fluid from the pumping system.

~~32.~~30. A pumping system according to any one of claims ~~27 to 31~~25 to 29 wherein the two pumps have a common delivery means and a common supply means, with appropriate valve systems controlling the sequence of operation.

~~33.~~31. A pumping system according to any one of claims ~~27 to 32~~25 to 30 wherein the or each pump is oriented so that the closed end of the tube structure is elevated in relation to the other end thereof.

~~34.~~32. A pumping system according to any one of claims ~~27 to 33~~25 to 31 wherein the delivery and exit of the actuating fluid to the actuating region is adjacent the closed end.

~~35.~~33. A pump for conveying a pumped fluid using a actuating fluid, the pump comprising a rigid outer casing defining an interior space, a flexible tube structure accommodated in the interior space, the interior of the tube structure defining a pumping chamber for receiving pumped fluid, the tube structure being movable between laterally expanded and collapsed conditions for varying the volume of the pumping chamber thereby to provide discharge and intake strokes, one end of the tube structure being closed and the other end communicating with a port through which pumped fluid can enter into and discharge from the pumping chamber as the pumping chamber performs the intake and discharge strokes, the region of the interior space surrounding the tube structure defining an actuating region for receiving actuating fluid, the pumping chamber being adapted to receive pumped fluid to cause the tube structure to move towards the expanded condition and the pumping chamber thereby undergoing an intake stroke, the pumping chamber undergoing a discharge stroke upon collapsing of the tube structure in response to the action of actuating fluid in the actuating region.

~~36.~~34. A pump according to claim ~~35~~ 33 wherein the tube structure is substantially inelastic.

~~37.~~35. A pump according to claim 35 or 36 wherein the port through which fluid enters the pumping chamber is at an opposed end to where the actuating fluid enters the pump.

~~38.~~36. A pumping system comprising

at least two pumps each having a pumping chamber accommodated in an actuating region,

a delivery means for delivering pumped fluid to each pumping chamber in timed sequence, causing each pumping chamber to undergo an intake stroke, and

means for supplying actuating fluid to each actuating region in timed sequence to cause ~~the~~ a respective tube structure of the pumping chamber to laterally collapse and the pumping chamber undergoing a discharge stroke,

whereby the sequential operation of the at least two pumps expels a generally uninterrupted supply of pump fluid from the pumping system.

~~39.~~37. A pumping system according to claim ~~38~~ 26 wherein each pumping chamber comprises a flexible and substantially inelastic tube structure.

~~40.~~38. A pumping system according to claims ~~38 or 39~~36 or 37 wherein the pumping chamber has one end closed and the other end connected to a port through which pumped fluid can enter into and discharge from the pumping chamber as the pumping chamber performs intake and discharge strokes.

~~41.~~39. A pumping system according to claim ~~40~~ 38 wherein the closed end of the pumping chamber is elevated in relation to the other end thereof.

~~42.~~40. A method of operating a pumping system in accordance with any one of claims ~~38 to 41~~36 to 39 wherein the duration of the discharge stroke of one pump is longer than the duration of the intake stroke of the other pump, and vice versa, whereby, when operated sequentially, the pumping system delivers a generally uninterrupted supply of fluid.

~~43.~~41. A pump for conveying a pumped fluid using an actuating fluid, the pump comprising a rigid outer casing defining an interior space, a tube structure accommodated in the interior space, the tube structure having one end closed and in an elevated position in to relation to the other end, which communicates with a port through which pumped fluid can enter into and discharge from the pumping chamber, the interior of the tube structure defining a pumping chamber for receiving pumped fluid, the tube structure being movable between laterally expanded and collapsed conditions for varying the volume of the pumping chamber thereby to provide discharge and intake strokes, the region of the interior space surrounding the tube structure defining an actuating region for receiving actuating fluid, the pumping chamber being adapted to receive pumped fluid to cause the tube structure to move towards the expanded condition and the pumping chamber thereby undergoes an intake stroke, the pumping chamber undergoing a discharge stroke upon collapsing of the tube structure in response to the action of actuating fluid in the actuating region.

~~44.~~42. A pump according to claim ~~43~~ 41 wherein the actuating fluid enters the actuating region adjacent the closed end of the pumping chamber.

~~45.~~43. A pump according to claims ~~43 or 44~~41 or 42 wherein the tube structure is flexible and substantially inelastic.

~~46.A method of operating a pump system comprising at least two pumps which, individually, supply a pulse flow, wherein the at least two pumps are operated in timed sequence to supply an generally uninterrupted discharge from the pump system.~~

~~47.A method according to claim 46 wherein the duration of the discharge stroke of one of the at least two pumps is longer than the duration of the intake stroke of the other of the at least two pumps and vice versa.~~

~~48.~~44. A pump as substantially herein described with reference to the drawings.

~~49.~~45. A pumping system as substantially herein described with reference to the drawings.

~~50.~~46. A method of operating a pumping system as substantially herein described with reference to figure 18.